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Mountains Majesty

Ecosystems of the Rocky Mountains

MAIN PHOTO BY LELAND HOWARD, WWW.WILDERNESSBOOKS.COM; INSET PHOTOS BY TALIE MORRISON

"A climb up the Rockies will…strengthen one's appreciation of the beautiful world outdoors and put one in touch with the infinite."
—Enos A. Mills, 1924

Traveling from the East, one can see the towering snow-covered peaks of the Rocky Mountains long before reaching the foothills. But to fully appreciate these mountains, one must venture into them and experience up close the colorful bursts of summer wildflowers, the glittering leaves of the quaking aspen, the cold clear alpine streams and lakes, and the distinctive sweet scent of the ponderosa pine.

by Elizabeth Rieben, Betsy Wooster, and Leah Quesenberry

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

The low-growing dwarf clover is adapted to living at high altitudes.

65 million years old — yet there is evidence of every geological process known to build mountains. Multiple events uplifted, folded, carved, erupted, and eroded the landscape over millions of years.

The most recent major event occurred between 70 million and 40 million years ago. Plates of the Earth's crust collided repeatedly, folding and piling on top of each other. This uplift drained an ancient sea that once occupied the center of what is now North America, and formed what we know today as the Rocky Mountains. Volcanoes, glaciers, and erosion have further defined and reshaped these mountains and valleys; signs of glacial and volcanic activity are evident throughout the region.

Current geologic activity is most obvious in Yellowstone National Park, which is underlain by molten rock that fuels its famous geysers. But the process of mountain shaping can be subtle, too. Wind, rivers, and streams erode mountains, while glaciers continuously gouge and scrape the rock over which they move. Water seeps into rocks, breaking them as it freezes and expands. Mountains may look static, but looks can be deceiving.

The Way West

The shape of the Rocky Mountains determined the routes of American Indians and later, early settlers, who sought the easiest way through the rugged terrain. This was through mountain passes, the same routes as many highways traverse today.

Historically, the easiest pass was South Pass in Wyoming. South Pass is a gently sloping rise that crosses the Continental Divide in the Wyoming Basin, a large upland plateau. An estimated half million pioneers bound mostly for Oregon, California, and Utah traveled through this pass.

Passes in the southern Rockies are steeper and more hazardous. And to the north, explorers Lewis and Clark ventured over treacherous Lolo Pass, an ancient Indian route crossing the rugged Bitterroot Mountains along the Idaho-Montana border.

Students at the McCall Outdoor Science School (MOSS) in Idaho smell the sweet scent of the ponderosa pine in Ponderosa State Park. The tree is also known as yellow pine for the distinctive hue of mature trees, and by children as the "puzzle tree" for its bark structure, which resembles puzzle pieces. Photo by University of Idaho, MOSS.

High Places

Extreme wind and cold characterize the forest tundra transition area between the dense subalpine forest and the treeless alpine tundra. Here, stunted trees grow in isolated clumps. "Flag trees" indicate the prevailing wind direction, with branches surviving only on their leeward sides. On the coldest and windiest sites, trees abandon their erect growth form and become shrubby mats. Limber and bristlecone pine trees grow into twisted forms as they cling to rocky knobs and ridges. Limber pines' flexible branches bend without breaking. The tree's scientific name, *Pinus flexilis*, refers to this adaptation. Bristlecone pines grow a limited number of new needles each year; each needle can perform photosynthesis for 10 to 15 years.

Key alpine plant adaptations are low-growth forms and small sizes. Many alpine plants also have extensive root systems to tap scarce moisture and nutrients, as well as to stay firmly anchored in windy conditions. Dense coverings of hairs protect sensitive leaves, shoots, and flowers from the drying effects of the constant wind.

Only a few animals can withstand the harsh winters of the alpine zone. The yellow-bellied marmot is an alpine rodent that hibernates through the winter, while the pika, a small, round relative of the rabbit, stays active, living off stored grasses and herbs. White-tailed ptarmigan have densely feathered feet that function like snowshoes. The chickenlike bird changes plumage from summer dark to winter white. Weasels undergo a similar change in color.

Adapting to Fire

Fire is a natural part of forest ecosystems in the Rocky Mountains and many plants have adapted to fire.

Ponderosa pine forests depend on fire to create open stands that let in sunlight. Low-intensity fires clear the forest floor and assist germination of ponderosa pine seeds. Seedlings thrive in the sunlit forest. The ponderosa pine's thick bark and deep roots protect it from fire and the trees' large buds are protected by insulating scales. In addition, mature trees tend to "self-prune," losing their lower branches. This keeps a surface fire from becoming a "crown" fire, one that advances from treetop to treetop.

Lodgepole pine trees produce both closed and open cones. Closed (serotinous) cones remain on the tree and are sealed with heavy resin until the heat from a high-intensity fire opens them and releases the seeds by the millions.

Canada lynx. The southern part of its range extends into the Rocky Mountains. Photo by Milo Burcham, U.S. Forest Service.

Elk not only need large habitat areas, but also require habitat corridors that connect their summer and winter ranges. Photo by Betsy Wooster, BLM.

A Place to Roam

Mountains often provide the only places where large predators can find unfragmented habitat to roam and hunt. Wolves and grizzly bears, for example, historically existed in a variety of ecosystems, but today exist in the Rocky Mountain region mostly in small populations in or near parks and wilderness areas. Both species are at the top of the food chain, helping to control the populations of other animals such as deer and elk.

The presence of top predators within an ecosystem can benefit many species of plants and animals. As part of an effort to restore the Greater Yellowstone Ecosystem, wolves were reintroduced to the Rocky Mountains in 1995. As their numbers have increased, the behavior of elk has changed. To protect themselves, the elk now move around more frequently. This, coupled with a slight decrease in elk populations, has relieved pressure on the riparian plants that elk eat. Trees, such as willows, cottonwoods, and even aspens are now flourishing, providing improved habitat for smaller animals and birds. A greater density and diversity of plants also assists in filtering water and combating erosion.

The Canada lynx is one of several wildcat species found in the Rocky Mountains. This predator follows a natural 7–10 year population cycle of "boom and bust" tied to the population of its favorite food, the snowshoe hare.

Management Challenges

The Rocky Mountains are managed by a variety of public agencies and private landowners. This public-private "checkerboard" ownership pattern evolved during the West's settlement, which started in the fertile mountain valleys. Much of the high mountain land was eventually set aside as National Forests and National Parks, while odd-numbered sections of land were given to the railroads to encourage construction of rail and telegraph lines. Although much of the Rocky Mountain area has been consolidated into manageable blocks of public or private land, the West's distinctive checkerboard ownership pattern still exists in some areas today. Land that was neither privately settled nor designated as parks or forests was called "public land." Today BLM manages this public land for multiple uses (such as outdoor recreation and oil and gas leasing) while protecting the natural, historical, and other resources of these lands.

Fragmented Habitat

A major challenge for land managers is to ensure suitable habitat for large and migratory wildlife species. Public lands generally provide the largest habitat blocks, but wildlife do not necessarily stay within these boundaries. For example, the reintroduced wolves (previously mentioned) now number some 300. They sometimes stray onto private lands and prey on livestock. Defenders of Wildlife, a non-governmental organization, reimburses ranchers for their losses, and the U.S. Fish and Wildlife Service works with other agencies and groups to address problems involving wolves. But the presence of wolves remains controversial.

Grizzly bears also need large, remote habitat blocks. Their numbers were reduced to just several hundred in the continental United States during the last century, but have increased to an estimated 1,200 since federal protection was granted in 1975. Still numerous in Canada and Alaska, grizzly bears in the lower 48 states are concentrated in the Yellowstone and Glacier National Park/Bob Marshall Wilderness areas of Wyoming and Montana. Lack of suitable habitat has been a major limiting factor, but in some areas, grizzly bear populations are expanding with better habitat management and greater public support.

A Growing Thirst for Water

Most large cities are located at the foot of the mountains, with the largest population centers along the Front Range on the eastern side of the mountains. As the area's population grows, so does the need for water, much of which comes from mountain streams and rivers. The Denver metropolitan region gets much of its water through extensive transmountain diversions. These diversions use reservoirs, underground tunnels, and ditches to move water from the wetter western side of the mountains to the drier eastern side, where four out of five Coloradans

live. As a result, some counties on the west side lose up to 65 percent of their streamflow.

Living With Fire

New homes in or adjacent to wildlands (undeveloped areas) create special challenges for land managers. Current federal policy seeks to reduce hazardous fuels that feed wildland fires. Millions of hectares of western forests contain high accumulations of flammable fuels, including "ladder fuels"—small trees and brush that carry surface fires up into tree crowns. To deal with hot crown fires, which pose risks to homes and communities, federal agencies are using thinning and prescribed (controlled) fires to reduce fire fuels. These fuel-reduction techniques help protect not only homes, but also power grids, drinking water, critical habitat, soils, and air quality.

Mountain Invaders

Hundreds of nonnative invasive plant species are affecting the economy and ecology of the Rocky Mountains. European cheatgrass has invaded significant portions of the region. Cheatgrass is highly flammable and sprouts quickly after a fire, increasing fire frequencies from every 60 years to every 2–4 years in some areas. Mountain shrub habitat is affected by invasive plants such as leafy spurge and a number of knapweed species. Some wetlands and streamsides at middle to lower elevations are covered with purple loosestrife, an invasive ornamental plant that crowds out the native wetland plants. This alteration of woodland and wetland habitat by nonnative invasive plants is believed to be a contributing factor in the general population decline of woodland bird species that spend the summer in the Rockies. Federal, state, county, and local land managers, and landowners, are mounting aggressive campaigns to stop the spread of these invasives into uninfested areas.

Development Pressures

Residential development is on the increase throughout the Rocky Mountains. Several key factors are spurring the West's growing population, including new jobs in recreation and energy development, new technology that allows workers to live almost anywhere, and an influx of retirees. As more private land is developed, public land becomes even more important in ensuring open space for people and for wildlife.

The Greater Yellowstone Ecosystem is an example. At 7.3 million hectares, it is the largest intact temperate ecosystem in the world, containing two national parks, seven national forests, and 12 wilderness areas, as well as private land, much of it under intense development pressure.

Here, large private ranches and farms adjoining public land provide much-needed open space, as well as edge habitat (the zone between two different types of habitat), and transitional zones between wilderness and inhabited areas. But many of these private properties are being subdivided into new residential developments, bringing cultivated lawns, pets, and other impacts to wildlife and water quality.

Partnerships are Key

Some creative partnerships have emerged to slow this loss of open space. The Green River Valley Land Trust in Wyoming encourages ranchers to place conservation easements on their property. A conservation easement limits development to protect certain resources while the landowner retains ownership.

Along the South Fork and Henry's Fork of the Snake River, proposed residential and resort developments threaten to fragment the river corridor habitat and diminish recreational opportunities by blocking public access. The BLM is working with partners to protect portions of the river corridor and public access to it. One recent conservation easement is preserving traditional land uses where a 60-lot subdivision, nine-hole golf course, and resort were proposed.

Because so many issues cut across jurisdictional boundaries, people are joining forces to tackle tough management challenges. The Blackfoot Challenge in western Montana, for example, involves 30 active partners, including private landowners, federal and state land managers, and local businesses. They have worked to restore and protect the Blackfoot River watershed in Montana through such efforts as planting native

High in the Rocky Mountains near Gunnison, Colorado, students from Western State College are studying the winter habitat of the Gunnison sage-grouse. Here, students are measuring sagebrush density, height, and percentage of leaf cover. Such research will help land managers plan for the birds' winter habitat needs in an area where development and associated activities are increasingly contributing to habitat loss. The Gunnison sage-grouse currently occupies only about 10 percent of the potential habitat available to it when settlers of European descent first began arriving in the West. Pictured are students John Stanek, Matt Vasquez, and Mary Oswald. Photo by Jessica Young, Ph.D., Western State College of Colorado.

Life at

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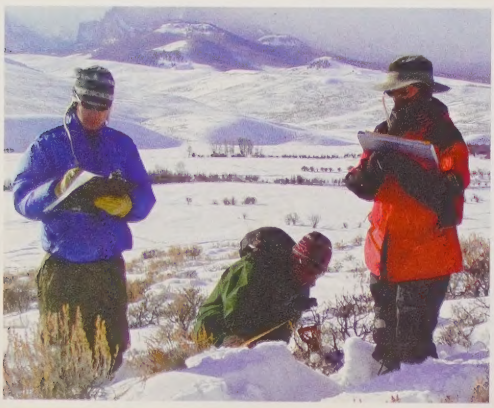

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Life at the Top

Rocky Mountain Ecosystems

Department of the Interior, Bureau of Land Management

Artwork and associated research by Shelly Fischman

ECOSYSTEM

The BLM worked with The Nature Conservancy to acquire a conservation easement to protect Fisher Bottom on the South Fork of the Snake River, which flows west from the Rockies through one of the most diverse ecosystems in Idaho. Photo by Karen Rice, BLM.

The Blackfoot River is born high on the Continental Divide and flows more than 200 km through several ecosystems in Montana. The area encompasses some of the most productive fish and wildlife habitat in the northern Rocky Mountains. Photo by Lee Walsh, BLM.

grasses, removing livestock feedlots from streamsides, and securing conservation easements.

But a primary goal is to protect the rural lifestyle of the people who live in the area by keeping large-scale development at bay. Toward this end, the partnership provides tours and workshops on rural values, sustainable agriculture, and alternative income sources such as ecotourism and guest ranching.

Rocky Mountain Tourism

With their scenic views, abundant water, substantial snow, and diversity of wildlife, the Rocky Mountains offer a variety of outdoor recreation opportunities, such as skiing, hiking, white-water rafting, fishing, and all-terrain-vehicle (ATV) riding.

The popularity of the Rocky Mountains requires land managers to enhance recreational and visitor services while raising public awareness about responsible ways to recreate on the public lands. The effects from such recreation are considerable. For example, food and trash left by visitors attract bears and other wildlife, which often become accustomed to humans. When hiking trails become crowded, some people may create their own trails and shortcuts. This can damage plants and compact the soil. Compacted soils do not absorb water, leading to erosion and the formation of gullies. Along streams, vehicle tires can damage fragile riparian and aquatic ecosystems or spread seeds of invasive plants to new areas. In response, land managers are working with a variety of recreation groups to implement education and outreach campaigns to reduce such impacts. These cooperative efforts involve local rider groups whose members help the government monitor vehicle activity on public land.

In fulfilling their multiple-use mission, BLM land managers seek to offer the widest array of recreational opportunities while minimizing impacts. Sometimes innovative approaches are necessary. For example, some river managers use a lottery system to keep river raft and boat traffic manageable during summer months. To maintain popular recreation sites and stay within budget, BLM sometimes collects special recreation fees. In addition, thousands of volunteers work in exchange for free campground sites and annual passes. Programs such as "Leave No Trace" and "Tread Lightly!" teach recreationists how to enjoy and respect the outdoors, fostering a personal outdoor ethic.

Going Underground: Mining and Energy Development

The Rocky Mountains contain valuable minerals and energy resources that contribute to America's economy, energy independence, and quality of life. Sources under the jurisdiction of the Interior Department, including BLM-managed lands, account for more than 30 percent of domestic energy production.

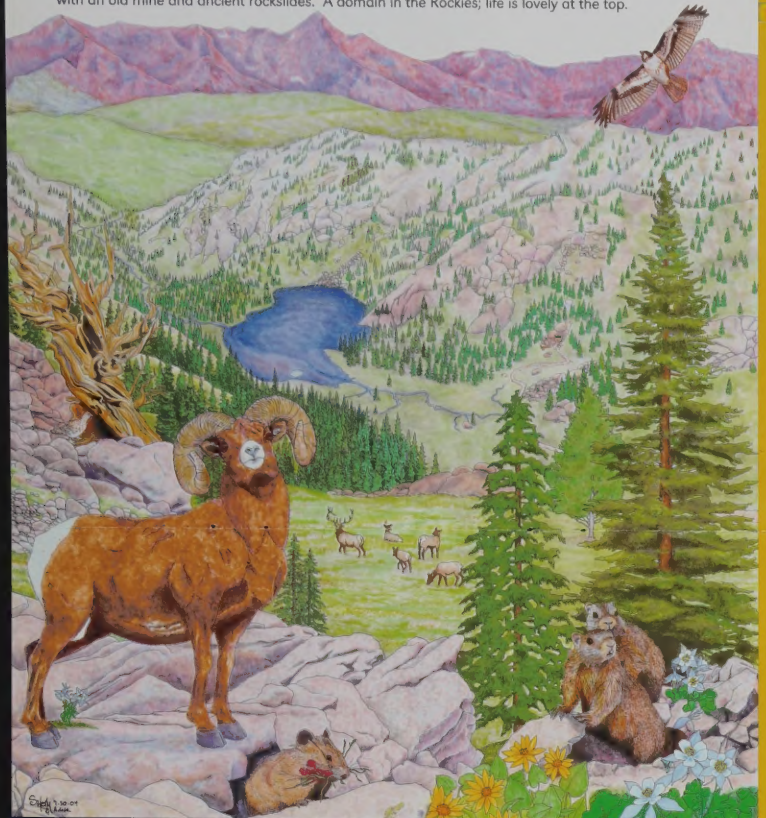
Many Rocky Mountain towns, such as Silverton, Colorado, and Butte, Montana, owe their beginnings to mining. The discovery of gold and silver attracted thousands of miners in the 1800s and successful prospectors obtained title to their claims through the federal government. Lead, zinc, and copper later spurred even more development, and today, copper, trona (soda ash), and coal are among the resources extracted from the Rocky Mountains.

In a previous era, mining often damaged the landscape. Today's mining is carried out with better tech-

Bikers ride along the Gold Belt Tour National Scenic Byway in Colorado, past one of many historic mine sites. Photo by Ruth Zirkle.

Meanwhile, up at the tree line.....

Two yellow-bellied marmots survey their domain from amidst clusters of blue columbine and yellow arnica, while overhead a red-tailed hawk rides the wind. The marmots' co-denizens on the mountainside include a pika with a mouth full of food and a majestic bighorn sheep. Less obtrusively, a ptarmigan lounges on the rocks at the base of a gnarled bristlecone pine. Should the marmots go down slope, they would find themselves first in the shade of a subalpine fir tree and then under an Engelmann spruce. Venturing further along to the meadow, they could rest in the shade of an aspen tree while observing a herd of grazing elk. In the glacially carved valley below, forests of conifers and a "hanging lake" share the silence with an old mine and ancient rockslides. A domain in the Rockies; life is lovely at the top.



U.S. Department of the Interior
Bureau of Land Management

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Rivers Run From It

Many of the most famous rivers in North America have their origins in the Rocky Mountains. The Rockies form the Continental Divide, which means that rivers originating there flow either to the Pacific or the Atlantic Ocean. In this activity, students will trace the paths of some Rocky Mountain rivers and then indicate the general location of the Continental Divide.

Materials needed

- a large wall map of North America
- access to research materials—encyclopedias, atlases, the Internet
- blue marker

Time required: 1–2 hours for research, map activity, and discussion

Procedure

1. Divide the class into groups and assign each group to research one of the following rivers:

Arkansas	Colorado	Columbia	Fraser	Missouri
Platte	Rio Grande	Snake	Yellowstone	Yukon

2. One at a time, have each group come to the map and trace the path of its river on the map with the blue marker. While one group member traces the path, another should describe the location of the river's source, any major cities along its path, and the body of water into which the river empties. If a river empties into another river, the path of that river should be traced until it reaches a major body of water—the Pacific Ocean, the Gulf of Mexico, etc.
3. Hold a class discussion on what the Continental Divide is—the sometimes sinuous line of mountain peaks and ridges that separate waters flowing into the Pacific Ocean from those flowing into the Atlantic Ocean via the Gulf of Mexico. If your students are familiar with the concept of watersheds, try to frame this discussion in terms of two major watersheds in the United States—the Atlantic and the Pacific.
4. Then ask one or more students to approach the map and indicate where they think the Continental Divide is located. Have them explain why they chose that location.
5. Compare their guesses to a map that shows the actual location of the Divide. (See the map in the article.)

Take a Trip

Time required: Will vary depending on extent of research; would probably work best as a long-term project (a week or more)

Whether they have visited the Rocky Mountains or not, students might like to plan their own imaginary trip there. To prepare for this activity, you and your students could write to state tourism boards in the Rocky Mountain states to request guides to tourist attractions and activities. Numerous websites can also assist with planning. (Try *www.recreation.gov*, for example.) Encourage students to think about all the recreational opportunities that abound in the mountains. Then have each student choose one activity, which will be the focus of a week-long adventure in the Rocky Mountains.

Encourage students to use their imaginations and their creative writing skills to describe their "trip." Have them describe where in the Rocky Mountains they went, what they saw, what they did when they got there, and why they chose this particular activity and location. Remind students to use descriptive adjectives and adverbs when writing about their imaginary experiences. If desired, you could add some math to this exercise by having students come up with a budget for their trip. Students could look into the cost of airfares, camping or lodging fees, supplies they would need, and so on.

Extension Activities

A Mixed Blessing

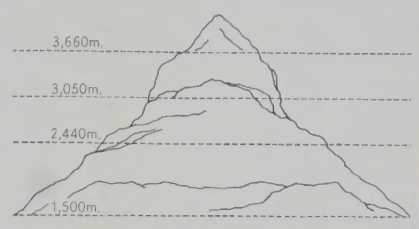
Tourism is big business in the Rocky Mountains, but with it can come big problems. Crowded campgrounds, damage caused by off-road vehicles, habitat loss caused by resort construction—these are just a few examples of ways that tourism can affect the mountain environment. Encourage your students to research ways in which their particular recreational choice (in the activity above) can have an impact on the environment of the Rocky Mountains. They might investigate how public land managers deal with some of these problems and how individuals can take personal responsibility for reducing the impact of their recreational pursuits. For ideas on this subject, they could consult the websites of Leave No Trace (*www.lnt.org*) or Tread Lightly! (*www.treadlightly.org*). Next, have students consider ways in which they can inform others about this issue. Perhaps they could prepare posters or write mock newspaper articles describing the situation.

Come for a Visit, but...

The Rocky Mountains attract not only tourists but plenty of people who want to stay in the area. Easy access to recreational opportunities is just one of the reasons why the population of several Rocky Mountain states has risen dramatically in recent years. Have students consult the website of the U.S. Census Bureau (*www.census.gov*) for more information on this topic. Students could compile charts and graphs to illustrate the data they find.

Zones of Life

Elevation plays the key role in determining the type of vegetation that predominates at different locations in the Rocky Mountains. Unlike areas with flatter terrain, where a particular biome—or life zone—may spread across a wide expanse, life zones in the Rockies change dramatically as the altitude increases. In this activity, students use research and artistic skills to create a poster illustrating typical life zones of the Rocky Mountains and present their findings to the class.



Materials needed

- large posterboard or bulletin board on which the mountain illustration (above) can be drawn on a larger scale
- art supplies
- access to research materials—encyclopedias; field guides to plants, especially trees; websites with information about plants, such as:

Time required: at least one class period for research and one for poster creation

Procedure

1. Redraw the mountain illustration on your posterboard or bulletin board, including the lines indicating altitudes. To keep the drawing to scale, create your own scale depending on the space you have available. For example, one-half inch on the small drawing could be one foot or one meter on your display.
2. Label the life zones on your mountain drawing as you discuss with students the different types of vegetation that might be found at different altitudes.
3. Divide the class into four groups and assign each group to research typical plants found in the following zones: Foothills; Montane Forest; Subalpine Forest; Alpine Tundra. See the chart in the article for specific examples. (Note: Be sure to point out to students that scientists can differ in their views on how to label life zones. There are few precise boundaries in nature!)
4. As students conduct their research, they should collect illustrations of the plants—not only close-ups to distinguish the different conifers, but also full-view shots so they can draw these on their section of the mountain. Each group should choose at least one artist to create the drawings. Others in the group can prepare talking points about the typical species, highlighting information on their requirements for growth.
5. Once all the groups have made their presentations, hold a class discussion on how altitude plays a role in some of the factors that affect plant growth in the Rocky Mountains. Such factors might include temperature, soil types, wind, and availability of moisture. Have students suggest other factors not related to altitude that might also affect plant growth. (The direction a particular slope is facing and the history of fire in the area are two possible suggestions.)

Extension Activities

- What's in a word? Students might note the use of the term to describe some of the life zones in the Rocky Mountains. The term refers to Europe's Alps, of course. Some students might be interested in researching this famous European mountain range, and then comparing and contrasting it with the Rocky Mountains.
- Students might also be interested in comparing and contrasting the plant life in their region with the types of plants found in the Rocky Mountains. Can they suggest reasons for similarities or differences?
- The types of plants in a particular life zone affect the types of animals found there as well. Have student groups investigate some typical animal species found in their life zones. Discuss why some animals might be found in one zone but not another. (Hint: Consider their habitat requirements.) Challenge students to identify some animals that migrate vertically—from one life zone to another—as the seasons change.
- For an activity that demonstrates how some evergreen trees depend on fire to reproduce successfully, check this link:

Aspen trees are one of only a few species of deciduous trees in the Rocky Mountains. They also are one of many species adapted to the fires that often occur there. A pioneer species, aspens are among the first to grow back after a fire. Each tree produces thousands of tiny seeds. A seedling sends out shallow, lateral roots that can send out new shoots, producing clones of the original tree. Because lateral roots often survive a fire, they can quickly establish a healthy young forest through this cloning process. In the absence of fire, coniferous trees eventually replace aspen. Fire is therefore important to maintaining aspen forests.

Rocky Mountain Animals – Then and Now

Time required: Will vary depending on extent of research; would probably work best as a long-term project (a week or more)

Early explorers and pioneers who traveled through the Rocky Mountain area were amazed by the variety and numbers of animals they saw. Have your students research and prepare reports on one of the following animals:

Bison	Grizzly Bear	Bald Eagle
Gray Wolf	Beaver	Snowshoe Hare

Reports should focus on the changes that have taken place in their populations over the past two centuries and on the current status of each. They could also include information on why changes have occurred and where these animals may be found today. In addition to encyclopedias, magazine articles, and books on natural history, websites on the Lewis and Clark expedition might be helpful starting points for research, as will the following:

- U.S. Fish and Wildlife Service Endangered Species website:
  (Note: Not all the above animals are endangered species.)
- eNature.com:
- National Museum of Natural History's North American Mammals:

Extension Activities

Copy the page at right for each of your students. Using books on animal tracks or the eNature website mentioned above, students should try to identify the three animals whose tracks are pictured in the illustration. Then have them write a story describing what they think might have happened. One possible scenario: Two **deer** coming toward the stream (from left) encounter a mountain lion, which is walking along the stream. The **mountain lion** sees them and starts to run and the deer begin to run as well (note the more widely spaced tracks). The mountain lion catches one deer (note the jumble of tracks) while the other escapes across the stream. Meanwhile a **raccoon** flees upon seeing the mountain lion.

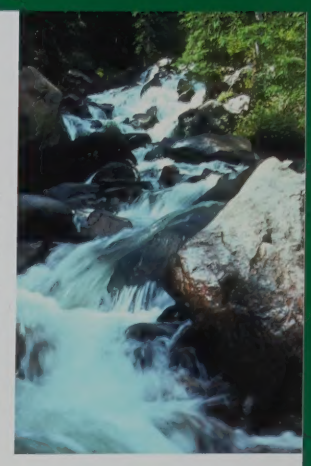
Native to cold Rocky Mountain rivers, the Greenback Cutthroat Trout was outcompeted for food, space, and spawning habitat as settlers began in the late 1800s to stock their own favorite sport fish. Colorado's state fish, the trout is a threatened species, although recent recovery efforts have helped to stabilize existing populations. Illustration by Joseph R. Tomelleri.

What Happened Here?

Can you figure out what animals visited the stream in the drawing below? Check some books on animal tracks or *www.eNature.com* to see if you can match the tracks with the following animals: mountain lion, deer, raccoon. Write the name of each animal next to its tracks.

Animal tracks can help you identify animals, and they can also help you learn about animal behavior. For an added challenge, you can write a story about what you think happened in the scene below.

Geology Rocks



The Rocky Mountains can serve as a primer on geologic activity for you and your students. Crustal movements, including folding, uplift, and volcanic activity, helped to create the high peaks, many of which are more than 4,000 m high. Forces of weathering and erosion went to work almost immediately and continue to shape the mountains today. In the following activities, which can also be performed as teacher demonstrations, you and your students can investigate some of the complex geologic processes that helped shape the Rocky Mountains.

Shaking It Up

Materials needed

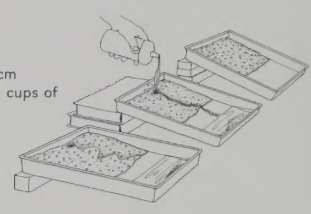
- ½ cup of small rocks—rough, not smooth (less than 3 cm in diameter)
- sturdy plastic container with top, capable of holding the rocks and approx. 1 ½ cups of water
- strainer
- balance scale
- stopwatch or timer

Time required: Overnight preparation of rocks; one class period or less

Procedure

1. Place the rocks in the container, add the water, and soak overnight.
2. Pour the water and rocks through the strainer, and then weigh the rocks. Note the weight on the chalkboard or have students make note of it in their journals.
3. Put the rocks and more water back into the container. Cover tightly.
4. Have the students take turns shaking the rocks and water, with each student shaking for about 2 minutes.
5. After a total of 20 minutes of shaking, strain the rocks and water again. Rinse the rocks.
6. Weigh the rocks again, and compare their weight with the previous measurement.
7. Ask students to explain what happened. (They should conclude that the tumbling action caused by the shaking caused tiny pieces of the rocks to come off—the same weathering action that occurs in a fast-moving mountain stream, for instance.)

It's All Downhill



Materials needed

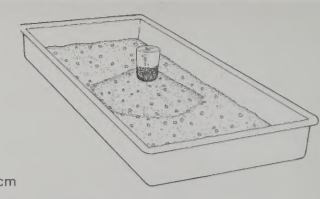
- 3 metal baking pans, approx. 20 x 30 cm
- a mixture of soil and gravel—approx. 2 cups of soil and 1 cup of gravel for each pan
- water in a plastic squeeze bottle
- 2 or 3 wooden blocks—each about 3 cm high (books also work)

Time required: One class period

Procedure

1. Place the soil and gravel mixture into one end of each of the baking pans to a depth of about 3 cm, as illustrated.
2. Take one of the blocks and place it under the soil-and-gravel end of one pan. This represents a low hill.
3. Squeeze water from the bottle in a slow, but steady, stream onto the top of the soil-gravel hill. Observe what happens.
4. Under the soil-and-gravel end of the second pan, place two blocks one on top of the other, thereby increasing the elevation of the hill. Again, squeeze water from the bottle, attempting to keep it flowing at the same rate as in step 3.
5. Repeat step 4 with another block underneath the end of the third pan, making the hillside even steeper.
6. Have students explain how the steepness of the hillside affected the rate of erosion.

Glaciers at Work



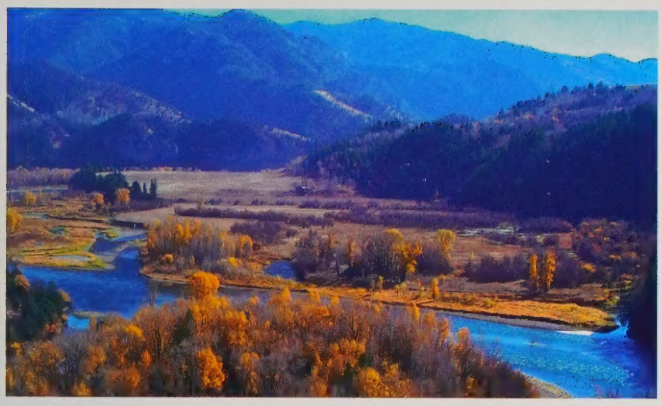
Materials needed

- Sand—approx. 2 ¼ cups
- Gravel—approx. 1 cup
- Water—approx. 1 cup
- small paper cup—approx. 175 mL
- access to a freezer
- metal baking pan—approx. 20 x 30 cm

Time required: Overnight preparation of "glacier" and then intermittent observations over a period of several days as the "glacier" melts

Procedure

1. Add equal amounts of sand and gravel to the paper cup to a depth of about 3 cm. Mix together well.
2. Add water to the cup to within about 2 cm of the top. Place the cup in the freezer overnight.
3. When you're ready to begin the experiment, place two cups of sand in the baking pan and add a small amount of gravel and enough water to make a "mountain."
4. Remove the cup from the freezer, peel off the paper, and place the frozen mixture (your "glacier") ice side up on top of the mountain.
5. Observe what happens as the glacier melts. Where do the rocks (the gravel) in the glacier go? Does the mountain change in appearance?



The BLM worked with The Nature Conservancy to acquire a conservation easement to protect Fisher Bottom on the South Fork of the Snake River, which flows west from the Rockies through one of the most diverse ecosystems in Idaho. Photo by Karen Rice, BLM.

The Blackfoot River is born high on the Continental Divide and flows more than 200 km through several ecosystems in Montana. The area encompasses some of the most productive fish and wildlife habitat in the northern Rocky Mountains. Photo by Lee Walsh, BLM.

grasses, removing livestock feedlots from streamsides, and securing conservation easements.

But a primary goal is to protect the rural lifestyle of the people who live in the area by keeping large-scale development at bay. Toward this end, the partnership provides tours and workshops on rural values, sustainable agriculture, and alternative income sources such as ecotourism and guest ranching.

Rocky Mountain Tourism

With their scenic views, abundant water, substantial snow, and diversity of wildlife, the Rocky Mountains offer a variety of outdoor recreation opportunities, such as skiing, hiking, white-water rafting, fishing, and all-terrain-vehicle (ATV) riding.

The popularity of the Rocky Mountains requires land managers to enhance recreational and visitor services while raising public awareness about responsible ways to recreate on the public lands. The effects from such recreation are considerable. For example, food and trash left by visitors attract bears and other wildlife, which often become accustomed to humans. When hiking trails become crowded, some people may create their own trails and shortcuts. This can damage plants and compact the soil. Compacted soils do not absorb water, leading to erosion and the formation of gullies. Along streams, vehicle tires can damage fragile riparian and aquatic ecosystems or spread seeds of invasive plants to new areas. In response, land managers are working with a variety of recreation groups to implement education and outreach campaigns to reduce such impacts. These cooperative efforts involve local rider groups whose members help the government monitor vehicle activity on public land.

In fulfilling their multiple-use mission, BLM land managers seek to offer the widest array of recreational opportunities while minimizing impacts. Sometimes innovative approaches are necessary. For example, some river managers use a lottery system to keep river raft and boat traffic manageable during summer months. To maintain popular recreation sites and stay within budget, BLM sometimes collects special recreation fees. In addition, thousands of volunteers work in exchange for free campground sites and annual passes. Programs such as "Leave No Trace" and "Tread Lightly!" teach recreationists how to enjoy and respect the outdoors, fostering a personal outdoor ethic.

Going Underground: Mining and Energy Development

The Rocky Mountains contain valuable minerals and energy resources that contribute to America's economy, energy independence, and quality of life. Sources under the jurisdiction of the Interior Department, including BLM-managed lands, account for more than 30 percent of domestic energy production.

Many Rocky Mountain towns, such as Silverton, Colorado, and Butte, Montana, owe their beginnings to mining. The discovery of gold and silver attracted thousands of miners in the 1800s and successful prospectors obtained title to their claims through the federal government. Lead, zinc, and copper later spurred even more development, and today, copper, trona (soda ash), and coal are among the resources extracted from the Rocky Mountains.

In a previous era, mining often damaged the landscape. Today's mining is carried out with better tech-

Bikers ride along the Gold Belt Tour National Scenic Byway in Colorado, past one of many historic mine sites. Photo by Ruth Zirkle.

nology and under laws and regulations aimed at ensuring environmental protection.

Rich Natural Gas Fields

While most U.S. oil and natural gas production takes place offshore, public lands in the West supply a significant amount of natural gas, a clean-burning fossil fuel mostly made up of methane. An oil and gas inventory by the Interior and Energy Departments in 2003 found that federal lands in five key western geologic basins contain nearly 140 trillion cubic feet of natural gas, enough to supply the 56 million homes that use natural gas for the next 30 years.

One area of interest for natural gas development is the Rocky Mountain Front. Here, the geological history set up unique conditions for the creation of rich supplies of natural gas. The key is an ancient seabed that provided organic debris as source material. Deep underground, heat turned this organic debris into oil and gas. Geologic movements of rock over time created underground spaces (reservoirs) that stored the oil and gas, with barriers on top that trapped them. As a result, experts believe there is a large reserve of natural gas trapped along the eastern mountain front in Wyoming and Montana. New technology makes extraction more feasible.

Balancing Multiple Uses

Because of an increasing demand for energy, the BLM is issuing more permits to drill on public land in and adjacent to the Rocky Mountains. Facilitating such energy development is a component of the BLM's multiple-use mission, though there is ongoing public discussion over how much energy development should occur in the Rocky Mountain region.

On BLM-managed public land, a lease and a permit to drill are required to remove oil and gas, and removal must be consistent with the BLM's land use plans, which are developed though a public process. The BLM issues permits after completing environmental analyses required by law. These permits can include stipulations to protect other resources, including wildlife migration routes and nesting areas. Operators are required to minimize environmental impacts during operation, protect important cultural and historic sites, and restore the disturbed site when drilling is completed. By law, energy development is off-limits in National Parks and in congressionally designated Wilderness Areas.

Public land managers seek to balance the national need for domestic oil and gas supplies with requirements to protect ecosystems while meeting all legal responsibilities.

Conclusion

The Rocky Mountains have always inspired awe and respect. Once considered a formidable barrier to be crossed on the way to places farther west, the Rockies today are one of the most sought-after destinations in the world. As more mountain land becomes developed, the open space provided by the public lands becomes increasingly significant. The challenge for public land managers is to conserve the natural resources that attracted people to the mountains in the first place, while allowing continued use and enjoyment of these diverse mountain ecosystems for many years to come. This can be accomplished with the active participation of those who use and care about the public lands, which belong to all Americans.

References and Resources

Kershaw, L.J. 1998. *Plants of the Rocky Mountains*. Lone Pine Publishing.

Lamb, S. 1995. *The Smithsonian Guides to Natural America: The Southern Rockies*. Smithsonian Books.

"Learning Landscapes," Bureau of Land Management *www.blm.gov/education*

National Energy Foundation. 1996. *Decision Making for Multiple Use Public Lands*. Salt Lake City, Utah.

National Historic Trails Interpretive Center, Casper, Wyoming. *www.wy.blm.gov/nhtic/index.htm*

Status and Trends of the Nation's Biological Resources: The Rocky Mountains. U.S. Geological Survey. *biology.usgs.gov/s+t/SNT/noframe/wm146.htm*

U.S. Geological Survey. Invasive Species Science Strategy for Department of the Interior Lands in the USGS Central Region. April 1, 2000.

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The Bureau of Land Management (BLM) is an agency of the Department of the Interior. The BLM manages about 105 million hectares of public land, mostly in the western United States and Alaska.